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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/040,548	01/04/2002	Katsuyoshi Matsuura	FUJ 99228 CON	3783

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EXAMINER	
LEE, HSIEN MING	

ART UNIT	PAPER NUMBER
2823	

DATE MAILED: 05/08/2003

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary	Application No.	Applicant(s)	
	10/040,548	MATSUURA ET AL.	
	Examiner	Art Unit	
	Hsien-Ming Lee	2823	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☐ Responsive to communication(s) filed on _____ .

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) 1-28 is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) 1-28 is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☒ The drawing(s) filed on 1/4/01 is/are: a)☒ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

11)☐ The proposed drawing correction filed on _____ is: a)☐ approved b)☐ disapproved by the Examiner.

If approved, corrected drawings are required in reply to this Office action.

12)☐ The oath or declaration is objected to by the Examiner.

Priority under 35 U.S.C. §§ 119 and 120

13)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____ .

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

14)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. § 119(e) (to a provisional application).

a) ☐ The translation of the foreign language provisional application has been received.

15)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☒ Information Disclosure Statement(s) (PTO-1449) Paper No(s) 4
4) ☐ Interview Summary (PTO-413) Paper No(s). _____ .
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other:

DETAILED ACTION

Claim Rejections - 35 USC § 102

1. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (e) the invention was described in (1) an application for patent, published under section 122(b), by another filed in the United States before the invention by the applicant for patent or (2) a patent granted on an application for patent by another filed in the United States before the invention by the applicant for patent, except that an international application filed under the treaty defined in section 351(a) shall have the effects for purposes of this subsection of an application filed in the United States only if the international application designated the United States and was published under Article 21(2) of such treaty in the English language.

2. Claims 1-2, 4-9 are rejected under 35 U.S.C. 102(e) as being anticipated by Okutoh et al. (US 6,201,271).

In re claims 1, 2, 4-7 and 9, Okutoh et al. in Fig.1 and related text expressly teach the claimed method of fabricating a semiconductor device having a ferroelectric capacitor, comprising the steps of:

- forming an active device element 3/4 (i.e. a transistor) on a substrate 1;
- forming an insulation film 6 (i.e. silicon oxide) over said substrate 1 to cover said active device element 3/4;
- forming a lower electrode layer 10/9/8 of said ferroelectric capacitor over said insulation film 6, wherein said lower electrode layer 10/9/8 includes depositing a Pt layer 10 and a Ti layer 8;
- forming a ferroelectric film 11 of a PZT (i.e. a film of zirconate titanate of Pb, see col. 1, line32 and col.5, line 60) by sputtering (col.8, lines 15-19) on said lower electrode layer 10/9/8 as a capacitor insulation film of said ferroelectric capacitor;

- crystallizing said ferroelectric film 11 by applying a rapid thermal annealing (RTA) in an atmosphere containing a non-oxidizing gas (i.e. nitrogen) and an oxidizing gas (i.e. oxygen) (col.6, lines 6-11); and
- forming an upper electrode layer 15 on said ferroelectric film 11;

  wherein said step of crystallizing said ferroelectric film 11 is conducted by setting a composition of said atmosphere such that said atmosphere contains said oxidizing gas with a fraction of 1 to 20% in volume (the ratio of nitrogen to oxygen is 4:1, i.e. nitrogen is 80% and oxygen is 20%, col. 6, lines 10-11).

In re claim 8, Okutoh et al also inherently teach that said ferroelectric film 11, PZT, has a perovskite structure because PZT has been known as a perovskite-type ferroelectric dielectric.

Claim Rejections - 35 USC § 103

3. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

4. Claims 10-13, 21, 23-28 are rejected under 35 U.S.C. 103(a) as being unpatentable over Okutoh et al (US '271) in view of Chu et al. (US 6,287,637).

In re claims 10 and 21, Okutoh et al teach all claimed step as stated above, including crystallizing the ferroelectric film PZT in the atmosphere containing non-oxidizing and oxidizing gases, wherein the atmosphere contains oxidizing gas (i.e. oxygen) with a fraction of 20% by

volume, but do not teach the step of oxidizing said ferroelectric film in an oxidizing atmosphere after said step of crystallizing.

However, Chu et al., in an analogous art of crystallizing the ferroelectric film, teach utilizing the atmosphere containing non-oxidizing gas (i.e. Ar, N2 or He, col.7, lines 62-65) and oxidizing gas (i.e. oxygen) followed by the step of oxidizing said ferroelectric film in an oxidizing atmosphere, i.e. Ar/O2 then O2 or N2/O2 then O2. (col.7, lines 29-40 and 62-65, Chu et al.).

Therefore, it would have been obvious to one of the ordinary skill in the art, at the time the invention wad made, to include the additional step of oxidizing the ferroelectric film after performing the crystallizing step as taught by Chu et al. in the Okutoh's method, since by doing so it would improve ferroelectric performance. (col.7, lines 29-40, Chu et al.)

In re claims 11, 12 and 13, Okutoh et al teach all claimed step as stated above, including crystallizing the ferroelectric film PZT in the atmosphere containing non-oxidizing and oxidizing gases, but do not expressly teach that the step is conducted under a reduced total pressure smaller than an atmosphere pressure in a range between 1 Torr and 40 Torr.

However, Chu et al., in an analogous art of crystallizing the ferroelectric film utilizing the atmosphere containing non-oxidizing gas (i.e. inert gas) and oxidizing gas (i.e. oxygen), teach that the crystallizing is conducted under a reduced total pressure with an oxygen partial pressure in the range of 10^{-4} to 100 Torr (col. 7, lines 25-28; col.8, lines 55-57).

Therefore, it would have been obvious to one of the ordinary skill in the art, at the time the invention wad made, to performing the crystallizing step of Okutoh et al under the reduced

total pressure as taught by Chu et al., since by doing so it would form a satisfactory perovskite structure in the ferroelectric dielectric film (col. 7, lines 2-5, Chu et al.)

In re claim 23, the aforementioned teachings of Okutoh et al in view of Chu et al teach that the non-oxidizing gas is selected from the group consisting of Ar, N2 and He (col.7, lines 29-32 and 62-65, Chu et al.; and col.6, lines 6-11, Okutoh et al.).

In re claim 24, the aforementioned teachings of Okutoh et al in view of Chu et al teach that the oxidizing gas is selected from a group consisting of O2 (col.6, lines 6-11, Okutoh et al .).

In re claim 25, the aforementioned teachings of Okutoh et al in view of Chu et al teach that the step of crystallizing the ferroelectric film is conducted by a rapid thermal annealing (RTA) process (col. 6, lines 6-11, Okutoh et al).

In re claim 26, the aforementioned teachings of Okutoh et al in view of Chu et al teach that the step of forming the ferroelectric film comprises the step of forming the ferroelectric film by a sputtering process (col.8, lines 15-19, Okutoh et al).

In re claims 27 and 28, the aforementioned teachings of Okutoh et al in view of Chu et al teach that the ferroelectric film has a perovskite structure (col.7, line 1, Chu et al.) and the ferroelectric film is a film of zirconate titanate of Pb (col. 1, line32 and col.5, line 60, Okutoh et al).

5. Claim 14 is rejected under 35 U.S.C. 103(a) as being unpatentable Cuchiaro et al. (US 6,165,802) in view of Zhu et al. (US 6,495,412).

Cuchiaro et al. in Figs.1-5 and related text teach the claimed method of fabricating a semiconductor device having a ferroelectric capacitor 118, comprising the steps of:

- forming an active device element 110 on a substrate 102 (Fig.1);
- forming an insulation film 114 over said substrate 102 to cover said active device element 110 (Fig.1);
- forming a lower electrode layer 116/120 of said ferroelectric capacitor 118 over said insulation film 114, wherein said lower electrode layer 116/120 includes a layer part 116 containing Ti;
- forming a ferroelectric film of a PZT (perovskite structure) 122 on said lower electrode 120 as a capacitor insulation film of said ferroelectric capacitor 118 (Fig.1);
- crystallizing said ferroelectric film 122 by applying a rapid thermal annealing process (step 226 in Fig. 2) (col. 8, lines 21-22) in an atmosphere of an oxidizing gas such as oxygen (col. 8, lines 20-30); and
- forming an upper electrode layer 124 on said ferroelectric film 122 (Fig.1)

Cuchiaro et al. do not expressly teach that the step of crystallizing the ferroelectric film is conducted by supplying O2 controlled to cause an oxidation in the Ti atoms reached a surface of the lower electrode from the layer part containing Ti atoms.

However, Zhu et al., in an analogous art of forming the ferroelectric capacitor, suggest that Ti atoms would migrate from the underlying adhesion layer (Ti) to the top surface of the lower electrode (Pt) and form chemical compound (i.e. TiOx) when the lower electrode and the Ti adhesion layer are subjected to RTA process (col.13, lines 46-51).

Therefore, it would have been obvious to one of the ordinary skill in the art, at the time the invention was made, to recognize that Cuchiaro et al. do inherently teach the aforementioned limitations, since the lower electrode layer 120 (Pt) is consecutively formed on the Ti layer 116

and Ti atoms from the layer 116 would migrate to the surface of the layer 120 during the crystallizing step. In other words, as the ferroelectric film 122 is subjected to the thermal annealing (i.e. RTA) for the crystallization the underlying adhesion Ti layer 116 and the lower electrode 120 are also exposed to the elevated temperature in the thermal annealing process. This would cause Ti atoms migrating from the Ti layer 116 to the top surface of the lower electrode 120 and form the TiOx, i.e. cause the oxidation in the Ti atoms reached a surface of the lower electrode 120 from the Ti layer 116 as claimed.

6. Claims 15-20 are rejected under 35 U.S.C. 103(a) as being unpatentable Cuchiaro et al. (US 6,165,802) in view of Izuha et al. (US6,060,735).

In re claims 15 and 16, Cuchiaro et al. also teach the claimed semiconductor device, comprising:

- a substrate 102;
- an active device element 110 formed on the substrate 102;
- an insulation film 114 provided over said substrate 102 to cover said active device element 110;
- a lower electrode 116/120 containing Pt 120 provided over said insulation film 114;
- a ferroelectric film of a PZT (perovskite structure) 122 provided on said lower electrode 120; and
- an upper electrode 124 provided on said ferroelectric film 12.

Cuchiaro et al. do not teach that said ferroelectric film having a columnar microstructure extending from an interface between said lower electrode and said ferroelectric film in a direction substantially perpendicular to a principal surface of said lower electrode, said

ferroelectric film essentially consisting of crystal grains having a generally uniform grain diameter of less than about 200 nm.

However, Izuha et al. (Figs. 1-7) in an analogous art teach the claimed semiconductor device, comprising a semiconductor substrate 1; a lower electrode 4 provided over the semiconductor substrate 1; a ferroelectric film 5 on said lower electrode 4 (Fig.1), said ferroelectric film 5 (perovskite structure such as PZT; col. 4, lines 52-53) having a columnar microstructure extending from an interface between said lower electrode 4 and said ferroelectric film 5 (Fig. 4A) in a direction substantially perpendicular to a principal surface of said lower electrode 4 (col. 2, line 57 through col.3, line 45), said ferroelectric film 5 essentially consisting of crystal grains having a generally uniform grain diameter of less than about 200 nm (col. 6, lines 52-53); and an upper electrode 6 provided on said ferroelectric film 5; wherein said lower electrode 4 comprises a Ti layer and a Pt layer (col. 4, lines 37-45).

Therefore, one of ordinary skill in the art, at the time the invention was made, would have been motivated to provide the semiconductor device of Cuchiaro et al., including the ferroelectric film, having a columnar microstructure extending from an interface between the lower electrode; and the ferroelectric film in a direction substantially perpendicular to a principal surface of the lower electrode, as taught by Izuha et al., with a reasonable expectation of success because Cuchiaro et al. and Izuha et al. are providing similar ferroelectric capacitor and by this manner it would provide the semiconductor device having a better dielectric breakdown resistance. (col.20, lines 55-60, Izuha et al.)

In re claims 17 and 18, the aforementioned teachings of Cuchiaro et al. in view of Izuha et al. also teach that the lower electrode 116/120 comprising a Ti layer 116 and a conductor layer 120 (i.e. Pt) provided on the Ti layer 116.

In re claims 19 and 20, the aforementioned teachings of Cuchiaro et al. in view of Izuha et al. also teach that the ferroelectric film has a perovskite structure and comprises a zirconate titanate of Pb (col.5, lines 52-57, Cuchiaro et al.).

7. Claims 22 is are rejected under 35 U.S.C. 103(a) as being unpatentable over Okutoh et al (US '271) in view of Chu et al. (US '637), as applied to claims 21 above, and further in view of Cuchiaro et al. (US '802).

Okutoh et al in view of Chu et al. teach all the claimed limitations as stated above, including lower electrode layer 10/9/8 includes depositing a Pt layer 10 and a Ti layer 8 (Okutoh et al.), but do not teach depositing the Ti layer and the Pt layer consecutively.

However, Cuchiaro et al., in an analogous art of forming a ferroelectric capacitor, teach forming a lower electrode layer 116/120 includes depositing a Ti layer 116 and a Pt layer 120 consecutively (Fig.1).

Therefore, it would have been obvious to one of the ordinary skill in the art, at the time the invention wad made, to modify the forming step of the lower electrode of Okutoh et al (US '271) in view of Chu et al. by consecutively depositing the Ti layer and the Pt layer as taught by Cuchiaro et al, since by doing so it would improve the adhesion between the lower electrode and the underlying insulation film (col.4, lines 61-65, Cuchiaro et al).

8. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Hsien-Ming Lee whose telephone number is 703-305-7341. The examiner can normally be reached on M-F (9:00 ~ 5:00).

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Olik Chaudhuri can be reached on 703-306-2794. The fax phone numbers for the organization where this application or proceeding is assigned are 703-308-7722 for regular communications and 703-308-7722 for After Final communications.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the receptionist whose telephone number is 703-308-0956.

W David Coleman
Primary Examiner
Art Unit 2823

Hsien Ming Lee
May 2, 2003